1/6/81

Dear Michael,

Thanks for your letter of 20 December. I am responding right away out of fear that if I put it aside to ponder I won't get around to responding until the spring! I hope I don't miss something, however, in the rush.

I think I'm beginning to see what you have in mind concerning locality and the correlation rule. As I formulate the rule, the following is true

$$[A \otimes I]^{\psi} = X_{m'} \text{ iff } [I \otimes B]^{\psi} = Y_{m''} \text{ iff } [f(A) \otimes I]^{\psi} = f(X_{m}$$

~~But, in general, $[A \otimes I]^{\psi} = X_{m'}$ iff~~

since $f(A) \otimes I$ is an eigenstate of ψ belonging to $f(X_{m'})$ if $A \otimes I$ is an eigenstate of ψ belonging to $X_{m'}$.

You (is this right?) want to eliminate the right-most link in this chain by reformulating the correlation principle so as to read

$$[A \otimes I]^{\psi}_{B} = X_{m'} \text{ iff } [I \otimes B]^{\psi}_{A} = Y_{m''} .$$

(Properly you'd probably want double subscripts, indicating which measurements are set on <u>each</u> component system.) Then we would have

$$[f(A) \otimes I]^{\psi}_{B} = f(X_{m'}) \text{ iff } [I \otimes B]^{\psi}_{f(A)} = Y_{m''}$$

Then if $\quad [I \otimes B]^{\psi}_{f(A)} \neq [I \otimes B]^{\psi}_{A} \qquad (\star)$

it follows that $f\left([A \otimes I]^{\psi}_{B}\right) \neq [f(A) \otimes I]^{\psi}_{B}$, and so the KS function rule cannot be derived (at least not as patterned on my derivation).

But notice that the non-locality involved in $(\star)$ is much more severe than usual. For usually we would suppose that the values on the B-system might change depending on which of

two incompatible msmts we make on the A-system. But (*) requires differences on the B-system for a pair of compatible A-msmts [A and f(A)]. Put differently, the Redhead Correlation Rule (the one with subscripts) is inconsistent with even a modicum of locality, that obtained by changing the '≠' in (*) to '='.

Finally, you point out that the Correlation Rule is a special case of what I call in Synthese '74 the "extended spectrum rule". But note that I show the extended spectrum rule to be inconsistent!

All this points towards the Redhead Correlation Rule being too strong. But it doesn't prove it so!

Now to your comments and questions on my paper. I enclose a slightly revised version; the revisions are mostly the added footnotes. I hope that your puzzle about responsible indeterminism is addressed by footnote *. The point is that the reduction to the deterministic case by looking at pairs (x, λ) as the real "hidden variable" makes no sense here since 'x' is just another description of the event in question. The only level of description that does make sense is the indeterminist one, and at this level factorizability fails for devices in harmony. Thus I think such devices represent the required counterexample: λ is the most complete possible specification of the state prior to the occurrence (or not) of the events; there is no exchange of information between systems about the barriers encountered; and still factorizability fails.

With regard to Nelson's Thm, you are quite right; I have certainly mis-stated Nelson's result, which is that the QM prob. distribution of $\tilde{S}$ differs from the prob. space distribution of S. (I think I must have been too immersed in calculations with 0, 1

random variables, where the average value fixes the prob. distribution.) Still, my claim that (CH) is a special case that falls under Nelson's Thm is correct. You can see this in several ways. One way is to note that the prob. distribution for S ($\tilde{S}$) is determined by the various <u>moments</u>, of which the average value is the first. Hence Nelson's Thm implies that in some state, some linear combination of $A', B, AB, \ldots A'B'$ will have a moment differing from that of the same linear combination of $\tilde{A}', \tilde{B}, \tilde{A}\tilde{B}, \ldots, \tilde{A}'\tilde{B}'$. (CH) then produces the singlet state, the combinations S, $\tilde{S}$ and ~~the~~ directs our attention to the first moment. Another way is to note that Nelson's Thm implies that in some state, some linear combination of $A', B, \ldots$ will have a prob for taking values in some interval I different from the prob that the same linear combination of $\tilde{A}', \tilde{B}, \ldots$ has for values in I. Then CH shows that the particular linear combination S has probability 1 for being in the interval $-1 \leq S \leq 0$. But $\tilde{S}$, in the singlet state ψ, does not have prob. 1 for falling between -1 and 0. Ok? Does that make the connections clear enough? (One of the nice things about Nelson's Thm is that it leaves entirely open the question of correspondence rules. <u>Any</u> way you correlate the observables with random variables (over the same space) in some state, some linear combination fails to have the right distribution.) Much thanks for pointing out my error in stating Nelson's result. I don't know if I can correct it in time for press, but at least <u>I</u> know it's wrong!

Enough QM. Regards to your wife, and best wishes for the new year.

Cordially,

Arthur